SEARCH FOR RELATIVELY STABLE SUPER HEAVY ELEMENTS IN NATURE BY FOSSIL TRACK STUDIES OF CRYSTALS FROM METEORITES AND MOON SURFACE.

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Introduction. The main goal of the present work is the search and identification of relatively stable nuclei ($Z \geq 110$) of Super Heavy Elements (SHE) in Galactic matter by fossil track study of non-conducting crystals excluding from the near-surface position of some meteorites and the Lunar regolite material.

As has been predicted theoretically [1], super heavy nuclei in the region of proton numbers $Z = 110$-114 and neutron number $N = 184$ (double ″magic″ closed shells of nuclei) can possess the life times from 10^3 up to 10^9 years. Such a nuclei of SHE can survive in the extraterrestrial rocks crystal and produce the tracks due to spontaneous fission if their life time is more than 5×10^7 years. Nuclei of SHE are supposed to be the products of nucleosynthesis in explosive processes in our Galaxy (Supernova r-process nucleosynthesis, and especially neutron star formation process, etc.) [2]. When these nuclei accelerated to relativistic energies in the Galaxy, they can produce extended trails of damage in non-conducting exposed crystals. To be registered in extraterrestrial crystals the lifetime of such SHE nuclei in the Galactic cosmic rays shall exceed $\sim10^3$ years. To search for and to identify the super heavy nuclei in the galactic cosmic rays it is proposed to use the ability of some extraterrestrial silicate crystals (olivine, pyroxenes, phosphates) to store for many million years the trails of damage produced by fast $Z \geq 23$ nuclei coming to rest in the crystalline lattice. The track length of fast $Z \geq 23$ nuclei is directly proportional to their Z^2. Thus, the nuclei of SHE shall produce the tracks by a factor 1.6-1.8 longer than the tracks due to high-energy galactic cosmic ray Th-U nuclei. For visualization of these tracks inside the crystal volume the proper controlled annealing and chemical etching procedures are used.

In our pervious study [3] the fossil tracks due to Th-U nuclei were first observed and unambiguously identified by calibrations of the olivine crystals with accelerated U, Au and Pb ions [4]. The charge distributions and the energy spectra of $Z = 26$-92 of galactic cosmic ray nuclei were first measured too. The number of Th-U nuclei track measured in olivine crystals was in total more than 1600, as compared with the rest world statistic – about 30 events on direct registration of $Z \geq 70$ cosmic ray nuclei tracks in satellite based detectors. Also the 5 anomalously long tracks that could not be attributed to Th-U nuclei were registered in our study. The main goal of the future track studies is the final unambiguous identification of $Z \geq 110$ nuclei in the galactic cosmic rays.

Synthesis of SHE. The present work was stimulated by recent synthesis and discovery of very stable isotopes of elements 110 – 116. During 1999-2000 in Flerov Laboratory of Nuclear Reactions, JINR it was succeed in the obtaining of a number of rather neutron – rich isotopes of elements 112,114 and 116, in the reactions of high-intensity breams of ^{48}Ca with monoisotopic targets of ^{238}U, ^{244}Pu and ^{248}Cm, respectively [5] The most stable isotope obtained is odd-even nuclide $^{285}112$, which possess the life time in between 10-30 min, as compared with 10-60 sec of some neighboring nuclei of $Z = 110$, 114 and few seconds-milliseconds for $Z = 116$, $Z = 106$-109 nuclei. Still the isotope $^{285}112$ has only 173 neutrons – 11 fewer as compared with the magic number $N = 184$. For the region of known actinide nuclei ($Z = 89$-98) such a neutron difference for light and the most stable isotopes provides the stabilization factor of 10^{10}-10^{13} in the life time. The discovery of new very stable isotope of element 112 provides first the final unambiguous proof on the existence of new island of very stable SHE nuclei, which has been predicted theoretically much earlier.

Results and calculations. In this report we are presented the new results and conclusions on search and identification of the fossil tracks due to cosmic ray SHE, observed and registered in meteoritic silicate crystals. We use here the olvine mineral grains extracted from pallasite meteorites. The total data obtained up to day allows us to obtain more reliable estimations of an upper limit of SHE abundance in the cosmic matter.

The main advantage of fossil track studies in extraterrestrial olivine crystals is the very long exposure time – about 200 my for Marjalahti and Lipovsky meteorites, for example. The crystals of these meteorites contain up to 10^2 Th-U cosmic ray tracks per cm^3. As it has been found in the previous study [3], the volume etchable track lengths of Pt-Pb and Th-U galactic cosmic ray nuclei in meteoritic olivine crystals annealed at 430^oC during 32 h was about 100-130 μm and 160-180 μm respectively. Still at these annealing conditions the group of 11 extra long tracks (L = 340-380 μm) has been found [6,7]. The correspondence of "fossil" and "fresh" – ^{208}Pb and ^{238}U tracks even more clear at the annealing conditions: T = 450^0C, time of annealing 32 h. In spite of rather low statistics, the single "fossil" track with the length of ≥ 250 μm was measured. The maximum track length of Th – U nuclei can not exceed 200 μm under these annealing conditions at any orientation in olivine crystal lattice. Detailed Laue roentgen and optical analysis shows that 5 out of 11 anomalously long tracks could not be produced by Th-U cosmic ray nuclei. Thus we already have the evidence of the existence of SHE nuclei; their abundance relative to the actinide elements is $\sim (3\text{-}10)\times 10^{-3}$.

Conclusions and proposal. Now we pointed out, that: There is no ways to get the neutron number N=184 using present day accelerators and target nuclei. The only one way to find out double magic SHE nuclei now is the search for these nuclei in natural samples.

The other more preferentially approach to identify SHE nuclei in the nature is to search for the spontaneous fission of Z ≥ 110 nuclei tracks in the extraterrestrial phosphate crystals, which are enriched by uranium. These nuclei produce 2- and 3-prong fission fragment tracks, which differ significantly from the tracks due to the spontaneous fission of ^{238}U and ^{244}Pu nuclei. The extraterrestrial phosphate crystals – whitlocites, apatites and stanfilldites – can be investigated in these studies. There are three main preferential possibilities: 1.The annealing behavior of spontaneous fission fragment tracks differs drastically in phosphates for actinides and SHE. The proper annealing (for instance, at 450^oC during 32h for Marjalahti whitlockite) provide the separation of fission fragment tracks due to ^{238}U - ^{244}Pu spontaneous fission and due to spontaneous fission of to Z ≥ 110 nuclei in volume etchable track length by a factor 2. The fossil track spectra must be compared with thermal neutron induced fission of ^{235}U nuclei track in the same crystals annealed at the same conditions. Such tracks shall provide some proofs of spontaneous fission of Z ≥ 110 nuclei existence. 2.The probability of ternary spontaneous fission of Z = 110-114 nuclei as compared with binary fission estimated to be 10^{-3}-10^{-4}. For actinide nuclei that ratio ratio is $N_{3f}/N_{2f} \leq 10^{-7}$. 3.These 3-prong tracks also shall have the mean length about 20% greater than binary tracks due to spontaneous fission of actinide nuclei.

Thus, the observation and measurements of such 3-prong spontaneous fission tracks in the volume of phosphate crystals shall provide the unambiguous proofs of SHE nuclei existence in Solar system.

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